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# A NEW CYSTOPHOUS CERCARIA FROM CALIFORNIA \*

W. W. CORT

School of Hygiene and Public Health, Johns Hopkins University

AND

ELINOR B. NICHOLS

Berkeley, California

A number of specimens of *Physa occidentalis* collected from Lake Temescal, a city reservoir near Oakland, California, were heavily infested with a new cercaria, to which the name *Cercaria californiensis* spec. nov. will be given. The infection was localized in the digestive gland of the snail. At the time that the examinations were made (September to December) there were found in the infected snails only rediae which contained cercariae. No sporocysts or rediae containing rediae were found.

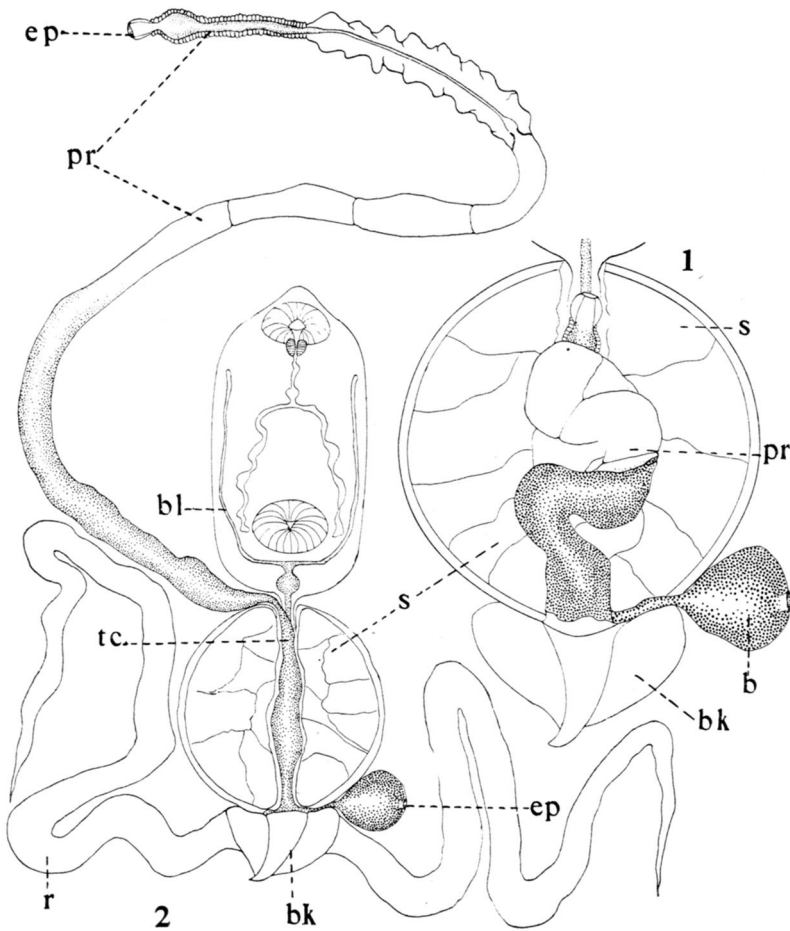
The rediae of this species vary considerably in size, ranging from 0.5 mm. to 1.6 mm. in length and have a width equal to about one-fifth or one-fourth the length. They are elongate sacs, slightly narrowed at the anterior end, and are without lateral projections. The body walls of a few of these rediae contain a pale orange pigment, the others being quite transparent. Contrary to what is usually observed in pigmented parthenitae, the pigment in this species appears in the immature rediae, the older ones being always unpigmented. The pharynx is small and the intestine extends about one-fourth of the total length. No birth pore is present. When the rediae are first freed from the digestive gland of the snail host they contract and expand actively for a few minutes, but are unable to move from place to place. Cercariae and developing germ balls fill the body cavity of the rediae from the posterior end to the region just behind the pharynx. The number of fully developed cercariae contained within a redia varies from eight to fifty. This great variation in number can easily be explained since in the absence of a birth pore all the cercariae which develop must remain within the redia.

The body of *Cercaria californiensis* (Fig. 2) is very small, having a length varying from 0.12 mm. to 0.18 mm. according to the state of contraction. The attachment between the tail and the body is weak, and is usually broken soon after the cercaria is freed

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from the redia for study. While still attached to the tail the cercaria was never seen to move about, but when it had broken loose it could locomote slowly by the use of its suckers. The body cannot be contracted into the tail, but always keeps the relation to the tail shown in figure 1 while within the redia and, when freed from the



redia, the position shown in figure 2. The size and position of the various organs of the body can be made out readily from figure 2. The ventral sucker is slightly larger than the oral and is in the posterior third of the body.

The mouth of *C. californiensis* is on the ventral side a little distance back of the pointed anterior tip. There is no prepharynx.

The pharynx is small and is followed by an esophagus of medium length (Fig. 2). The intestinal ceca extend back to the level of the ventral sucker.

Of the excretory system only the parts of the bladder were distinguished (Fig. 2, *bl*). The undivided portion of the bladder has a globular enlargement containing the highly refractive concretions which are so commonly found in the excretory bladder of cercariae and agamodistomes. It is connected by a narrow tube with the excretory tubes of the tail. The bifurcations of the bladder were traced forward to a point just back of the pharynx. The region of the bifurcations nearest the enlargement and the tube leading into the tail also contain the concretions. The peculiar relations of the excretory canals in the tail will be discussed later.

The tail of *C. californiensis* is very remarkably differentiated. Figure 1 shows its appearance when the cercaria is within the redia or just after it has been forced out. In this condition the tail appears as a large firm cuticular sphere (Fig. 1, *s*) with two short projections at its posterior end (Fig. 1, *bk* and *b*). One of these projections has the form of a cuticular beak (*bk*). It is entirely transparent and is divided into a central area which is pointed posteriorly and two lateral areas. The beak is so transparent that nothing can be seen of the ribbons (Fig. 2, *r*) which are later extruded from the lateral areas. To one side of the beak is a bulb (Fig. 1, *b*) with an opening on its outer surface. This bulb is loaded with excretory concretions. The sphere has a thick cuticular wall and is very difficult to break when pressure is applied on the cover glass above it. The sphere has a central column of living material (Fig. 2, *tc*) along which is folded a very complex cylindrical structure. The portion of the sphere between the central column and the wall is highly vacuolated. The posterior region of this body is directly connected with the column of the sphere, and a tube from the excretory bladder of the body extends down into this column.

Soon after the cercaria is freed from the redia two flat transparent cuticular ribbons (Fig. 2, *r*) are extended out laterally from the sides of the beak. These ribbons are pointed and have no apparent structural differentiation. At the same time there is slowly protruded from the place where the body joins the tail sphere the long cylindrical projection which, in the condition indicated in figure 1, is folded along the column of the sphere (Fig. 1, *pr*). This structure, which will be called the excretory projection, is protruded until it has a length more than three times that of the body of the cercaria (Fig. 2, *pr*). The excretory projection is a hollow cuticular cylinder. The proximal half of this cylinder is undifferentiated, has a very

thin wall and contains excretory concretions. Beyond the middle the excretory projection appears to be jointed externally. At about the beginning of the distal third of the excretory projection the cuticular wall becomes much thicker, narrowing the lumen. In the first half of this region the greatly thickened cuticula appears to be ruffled. Distal to this region the lumen widens slightly and the cuticula appears to be fluted. The excretory projection ends with a dilation followed by a cup-like structure with a large opening at its end. The first half of the excretory projection and the last fluted part contain excretory concretions. The excretory projection is broadly attached to the posterior part of the column of the tail (Fig. 2, *tc*). The differentiations of the excretory projection are shown in figure 2.

The presence of excretory concretions in various parts of the tail of *C. californiensis* indicates the relation of these parts to the excretory system. There are two openings of the excretory system in the tail (Fig. 2, *ep*), one on the outer surface of the excretory bulb, and the other at the end of the excretory projection. The excretory bulb is directly continuous with a tube which runs from the bladder of the body down the column of the tail. The lumen of the excretory projection is also directly connected with this tube. These connections are indicated by the presence of the concretions in the various structures. Movements of the concretions could be followed from the tube in the column of the tail into the excretory bulb. Excreta from the body of *C. californiensis* can escape after passing down the column of the tail-sphere either by the pore of the excretory bulb or after passing along the excretory projection from the opening at its end.

Apart from the relation to the excretory system described above, it is difficult to suggest functions for the various parts of the tail of *C. californiensis*. The function of the tail of a cercaria is evidently to aid it in that period of activity, usually including a short period of free life, from the time it leaves its parthenita until it is settled in its secondary intermediate host, its final host, or is encysted in the open waiting to be taken into its final host. We have no direct evidence in regard to the further development or activities of *C. californiensis*. There are certain things, however, which it is perfectly evident that this cercaria does not do. The absence of a stylet and cephalic glands and the weak muscular development of the body of the cercaria make it evident that it does not penetrate actively into the next host. The absence of cystogenous glands in the body and the inability to withdraw into the vesicle of the tail show that it does not encyst in the open and wait to be taken into its next host. Finally

the fact that the redia has no birth pore, that the cercariae accumulate in the redia and that they are practically incapable of locomotion in the open, makes it very probable that this cercaria never leaves its intermediate host and continues its development in some vertebrate which feeds on this host.

There is nothing in such a life cycle which would make it possible to explain the complex structure of the tail of *C. californiensis* in terms of function. The fact that in three closely related forms *C. cystophora* (Wagener, 1866), *C. sagittarius* (Ssinitzin, 1911:15-19), and *C. yoshidae*\* (Yoshida, 1917) the body of the cercaria can be withdrawn into the tail for protection suggests that this is the primary function of such a vesicle as the sphere of *C. californiensis*. A change in life cycle which eliminated the free stage and therefore the importance of this function may have led to the loss of the power of withdrawal into the tail vesicle without the loss of that structure. It is still more difficult to determine any function for the appendages of the tail. Ssinitzin, (1911:18) suggests that the various appendages of the tail of *C. sagittarius* hold the tail vesicle, which forms a cyst containing the cercaria, in position in the digestive tract of the final host until the cercaria has had a chance to get out of its cyst. Such a function for the excretory projection and ribbons of *C. californiensis* seems very improbable since in the first place this cercaria does not become encysted in the vesicle of the tail and in the second place the body is so weakly attached to the tail that even a slight pull will break the connection. It is, of course, possible that these appendages may also represent structures which have lost their function through modifications of the life cycle. Finally it is very probable that structures may develop in connection with the evolution of such a diversified organ as the cercaria tail which have no function whatsoever.

*C. californiensis* belongs to a small group of cercariae which Ssinitzin (1911:20) named the Cystophrous Cercariae. He characterizes this group as containing cercaria which possess a vesicular tail with various appendages. The first cercaria of this type to be described was *Cercaria cystophora* which Wagener (1866) reported from *Planorbis marginatus*. Another cercaria which probably belongs to this group was described by Sonsino (1892) from *Cleopatra bulimoides* as *C. capsularis*. Sonsino's original description is hardly sufficiently detailed to make the relationship of this species clear. The same cercaria is later described in the immature state by Looss (1896). These two descriptions taken together make it pretty certain that

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\*I use this name to designate the species which Yoshida describes as *Cercaria* F.

this form belongs to the cystophorous cercariae, but do not give enough data to make a detailed comparison possible. Pelseneer (1906) described two marine representatives of this group, *C. appendiculata* from *Natica alderi* and *C. vaullegeardi* from *Trochus cinerarius*. Later Ssinitzin (1911: 15-21) described two more marine cystophorous cercariae, *C. sagittarius* from *Cerithium exille* and *C. laqueator* from *Rissoa venusta*. Finally there should be added to this group *C. yoshidae* (Yoshida, 1917) from *Melania libertina* from Japan and *C. californiensis*. While the cystophorous cercariae vary considerably in structural details, they have so many important points in common, that we consider that they form a natural group.

All the cystophorous cercariae except *C. vaullegeardi* (Pelseneer) develop in rediae. Mother sporocysts in which the rediae develop have been described for two species, *C. sagittarius* Ssinitzin (1911: 15) and *C. cystophora* (Wagener, 1866). In none of the species were rediae which contained rediae found and the descriptions of the two species of which the mother sporocysts were found, indicates that such a stage is not present in the life histories of the members of this group. The rediae are much alike having no locomotor appendages, a very small pharynx and a voluminous digestive tract varying from one-fourth the length of the redia in *C. californiensis* to two-thirds its length in *C. yoshidae*.

The body of the cercariae in all cystophorous cercariae is very small and the primordial adult characters are very slightly developed. This is indicated by the small size, the lack of clear differentiation of the organs and the short distance between the ventral sucker and the posterior end. The bodies of these cercariae lack entirely all adaptive larval structures for penetration and encystment, i. e., stylet, cephalic glands and cystogenous glands. The digestive system in those forms for which it has been described is much like that of *C. californiensis* (Fig. 1), except that the length of the intestinal ceca varies. The excretory bladder is y-shaped.

The tails in these forms differ considerably in detail, but are all built on the same fundamental plan. There is present in each species a central vesicle or sphere as we have called it in *C. californiensis*. This is a firm structure with a thick cuticular wall which was evidently developed to function as a cyst into which the cercaria can be withdrawn into the cavity of the sphere as in *C. sagittarius*, *C. cystophora*, *C. yoshidae*. In regard to *C. laqueator* and *C. californiensis* the statement is made that the body of the cercaria cannot be withdrawn into the vesicle of the tail. It is evident that this ability of the cercaria to withdraw into the tail would be a very important protective measure

at the time of entrance of the cercaria into its next host. Besides the central vesicle there is found in every species of this group a protractile appendage comparable to the structure we have called the excretory projection in *C. californiensis*. This structure differs greatly in the various species and in some is not sufficiently described for comparison. The various other appendages which are found on the tails of the Cystophorous cercariae are so remarkably varied and grotesque that it is not only impossible to get an idea of what their function may be, but also there seems to be no homologies which can be worked out between them.

Further development is known for only one of the cystophorous cercariae, *C. cystophora*, which develops into *Haliëgus ovicaudatus* which is found in the mouth cavity of the European frog. Ssnitzin (1905 and 1907) finds the agamodistine stage of this species free in the body cavity of the nymph of the dragon-fly *Calopteryx virgo*. On this account he suggests (Ssnitzin, 1911:21) that the life cycles of the other members of this group will probably follow the same course. This deduction does not seem to us to necessarily follow since a fundamental modification of life cycle might come to a species, and yet the structural adaptations for the previous mode of life might be retained. Certainly in the case of *C. californiensis* there could hardly be a secondary intermediate host, since it seems very improbable that this cercaria ever leaves its molluscan intermediary.

#### SUMMARY

1. *Cercaria californiensis*, a new species of cercaria from *Physa occidentalis*, has a very small body which shows no adaptive larval characters and but slight development of primordial adult characters.
2. The tail of this species is very remarkably differentiated, consisting of a central cuticular vesicle, the sphere, and various projections and appendages.
3. It is not possible to explain the functions of the parts of this tail in terms of activities of the cercaria since the cercaria probably never leaves the redia within its intermediate host.
4. *Cercaria californiensis* belongs to a natural group, the cystophorous cercariae which are characterized by a small, very slightly differentiated body and an extremely complex tail consisting of a central cuticular vesicle, with various appendages.

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